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CHALCID CONTROL IN ALFALFA-SEED PRODUCTION

UNITED STATES DEPARTMENT OF AGRICULTURE

THE CLOVER-SEED CHALCID is a small wasp-like insect which has become a serious pest of alfalfa seed in the western part of the United States. This bulletin contains a brief account of the life history and habits of the chalcid and of the nature and extent of its damage to the alfalfa-seed crop. Investigation and experience have shown that the losses caused by this insect are greatly reduced when the practices described and recommended herein are put into effect by alfalfa-seed producers.

This bulletin is a revision of and supersedes Farmers' Bulletin 636, The Chalcis-Fly in Alfalfa Seed.

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CHALCID CONTROL IN ALFALFA-SEED PRODUCTION

By V. L. WILDERMUTH, *Senior Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology*

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INTRODUCTION

THE CLOVER-SEED CHALCID [1] (fig. 1, *a*) has for years been one of the most serious factors in reducing the annual crop of alfalfa seed in many parts of the seed-producing areas of the country.

Various investigators have been studying this pest in an effort to work out some definite plan for checking the damage caused each year. In 1914 the department published a bulletin, The Chalcis Fly in Alfalfa Seed, reporting the results of some of the preliminary investigations, and in 1920 a more complete bulletin, The Clover and Alfalfa Seed Chalcis Fly, was published on the detailed life-history studies of the insect. Since these dates much additional information has been acquired, and certain cultural methods have been developed whereby an individual farmer or a group of farmers may greatly reduce the losses caused by this pest.

The problem has not been completely solved, and certain lines of investigation are still being conducted which, it is hoped, eventually will make possible a still more definite procedure for controlling the insect if not entirely preventing the major portion of the damage.

A discussion dealing with the control of this chalcid in the alfalfa seed producing sections of the United States must necessarily be of a general nature because the conditions of climate and field operations vary so greatly in the different localities. It is believed, however, that the information given in this bulletin will assist

[1] This insect is also called the clover-seed chalcis-fly, and in the western part of the United States it is commonly known as the alfalfa-seed chalcis fly. It is known scientifically as *Bruchophagus funebris* Howard; order Hymenoptera, family Eurytomidae.

greatly in enabling a seed producer to prevent a portion of the loss caused by this pest.

DISTRIBUTION

At present the clover-seed chalcid occurs to a greater or less extent in practically every locality where either red-clover or alfalfa seed is produced. It seems to reach its greatest numbers in irrigated sections in the Western and Southwestern States where alfalfa seed is a crop of considerable importance. It also occurs in destructive numbers in the large alfalfa-growing areas in the Mid-Western States. Alfalfa seed imported from many foreign countries, including Germany, Turkestan, Chile, Turkey, and Siberia, has contained this insect.

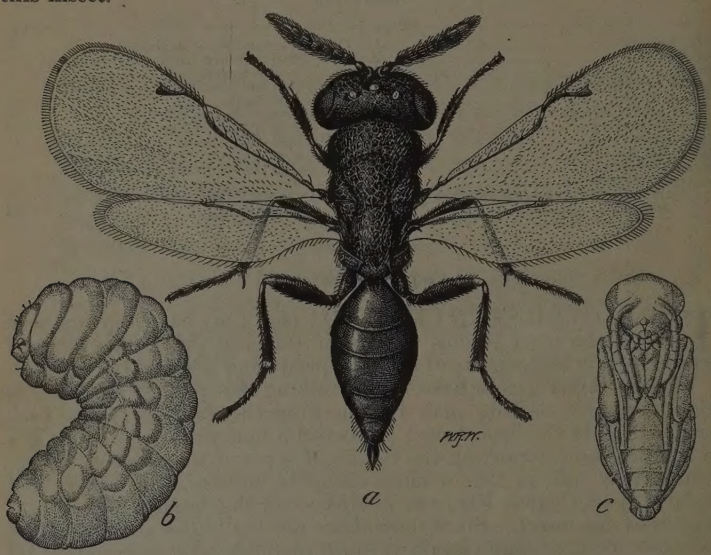

FIGURE 1.—The clover-seed chalcid: *a*, Adult; *b*, larva; *c*, pupa. Adult about thirty times natural size; larva and pupa about twenty-five times natural size

MEANS OF SPREAD

It seems possible that this chalcid is a native of the United States, as it was originally described from this country. The spread of the insect, however, has been hastened by the shipment of infested seed from one district to another. There is a heavy trade in alfalfa seed over the United States, and seed from badly infested districts is constantly being shipped to other sections. Such shipments nearly always contain infested seeds inclosing hibernating larvæ; consequently, under present methods of seed distribution, the pest has rapidly become established in all alfalfa-seed districts.

The insect, being a strong flier, often ascends high in the air over an alfalfa field and is wind-blown to neighboring alfalfa fields, and the spread in any one locality is dependent largely upon wind.

Seed pods are also doubtless carried by mountain streams or rivers and are then lodged in irrigated fields, where the insects emerge and infest the alfalfa growing there.

EXTENT OF INJURY

The loss occasioned by the chalcid in alfalfa seed is of large proportions, and it is hard to estimate for the seed-producing areas taken as a whole. The extent of damage is influenced by many different factors and is not constant from one year to another. From records made by various workers it has been found that from 2 to 85 per cent of the alfalfa seed may be infested in any given crop, and this infested seed is of course always lost. In some fields the loss may amount to less than 30 pounds of seed per acre for the year, while in other fields, possibly in the same locality or in different localities, the loss may run as high as 300 pounds per acre.

An example of the injury caused by this insect is taken from the records of Arizona for 1927. That year 22,000 acres were devoted to alfalfa-seed production in the State. Accurate counts and records were made of a great majority of the alfalfa-seed fields, and it was estimated that the loss sustained was approximately 70 pounds for every seed-producing acre in the State, which meant a loss of over 1,500,000 pounds of seed. When it is realized that this State produces about 10 per cent of the total of alfalfa seed produced in the United States and that the insect occurs in damaging numbers in many of the other districts, it can be realized that a large loss is occasioned each year by the work of this pest.

A great many seed growers do not appreciate the damage that this insect is causing because of the fact that its work is carried on within the growing seed. At harvest time, when a poor seed yield results from what appeared to be a well-podded crop of alfalfa, they do not realize that the chalcid-infested seeds, which have blown over with the screenings and have disappeared in threshing, have reduced their crop yield. Therefore it would be well for seed growers to watch closely their alfalfa-seed crop and to look for the emergence holes in the seed pods; then, by shelling out a number of these pods and looking for the dark-brown seeds or the seeds with holes in them, they will be able to estimate something of the damage to be expected. Figure 2 shows a sample consisting of 2,000 alfalfa seeds from an alfalfa field where 78 per cent of all the seeds were infested by the chalcid. This 80-acre field produced 60 pounds of recleaned alfalfa seed per acre, but the infested seed amounted to 202 pounds per acre, which, at the then current price of 17 cents per pound, meant a loss of more than $2,700 for the 80 acres. In a given locality the loss from this chalcid is usually much greater in late-maturing crops than in early-maturing crops. This is largely due to the fact that as the season advances the insect increases in numbers. Exceptions to this rule are often noticed where parasites, which will be discussed later in this bulletin, have reduced the number of chalcids. The early alfalfa pods found along ditch banks or fence rows are often heavily infested by larvæ of the first generation.

In seed-growing districts where bur clover is present in large quantities, the pods from these plants often shelter individuals of

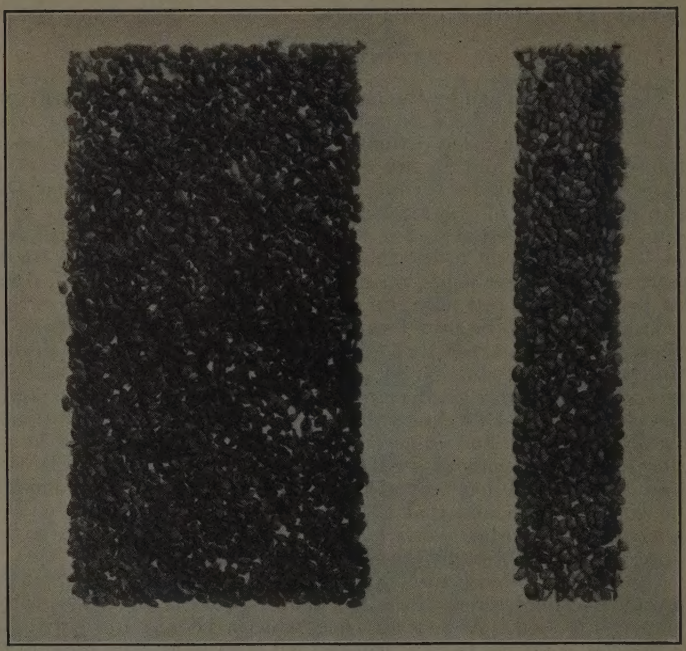

FIGURE 2.—A sample of alfalfa seed containing 2,000 seeds, 78 per cent (at left) being infested or destroyed by chalcid larvæ. About one and one-fourth times natural size

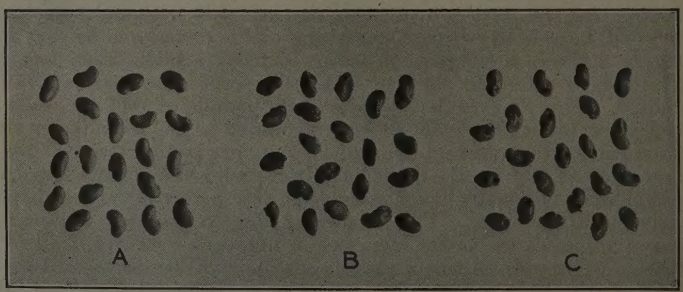

FIGURE 3.—A comparative view of alfalfa seeds: A, noninfested seeds; B, infested seeds containing larvæ; C, empty seeds from which chalcids have already emerged. About twice natural size

the first generation and in this way greatly complicate the problem of alfalfa-seed production.

TYPE OF INJURY

This insect injures the seed of alfalfa, bur clover,[2] and red clover, but does not in any way affect the growth of these plants for forage or hay. It is only when an attempt is made to produce seed that damage is noticed. A seed that is infested by a chalcid larva is an entire loss to the seed grower. The infested seed becomes very dark brown, at times nearly black (figs. 3, B, and 4), and lacks the luster that is characteristic of a healthy uninfested seed. A seed from which a chalcid adult has emerged is entirely hollow (figs. 3, C, and 5) and shows the round hole from which the adult insect has escaped. These seeds are blown over with the screenings when the seed crop is threshed or hulled. The alfalfa and bur-clover pods (fig. 6) show round exit holes like those in the seed, and these holes are usually located directly over those found in the seed inside.

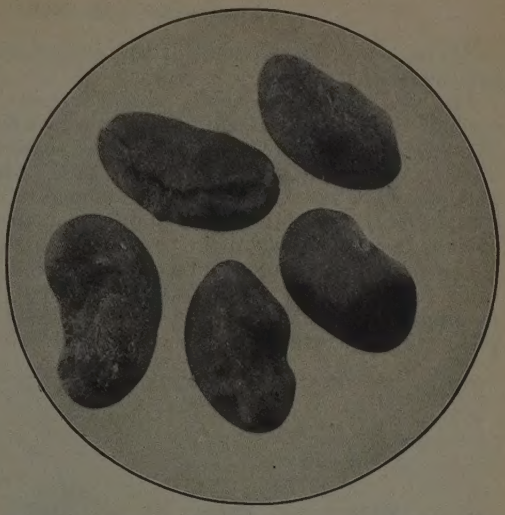

FIGURE 4.—Infested alfalfa seeds containing the hibernating larva of the chalcid. About twelve times natural size. (Urbahns)

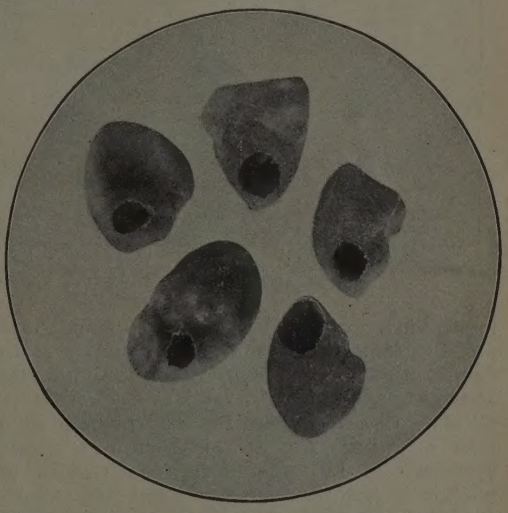

FIGURE 5.—Alfalfa seeds which have been hollowed out by the larvæ and from which the adult chalcids have emerged. About twelve times natural size. (Urbahns)

[2] Bur clover is of two kinds, known scientifically as *Medicago hispida* Gaertn. and *M. hispida denticulata* (Willd.) Urban.

STAGES OF THE INSECT

All stages of development of this insect are completed within the infested seed.

The adult deposits a single, minute egg, invisible to the naked eye, through the soft green seed pod directly into the soft developing seed. The eggs are deposited while the seed pods are from one-fourth to one-half grown, at which time the seeds within are small watery particles showing very slight development. The eggs hatch in from 3 to 12 days, depending upon the temperature at the time development is taking place.

Under average temperature conditions the larvæ (fig. 1, *b*) begin their feeding a day or two after hatching. These larvæ continue feeding within the tender growing seeds, and most of them have completed their growth by the time the pods have ripened. When these

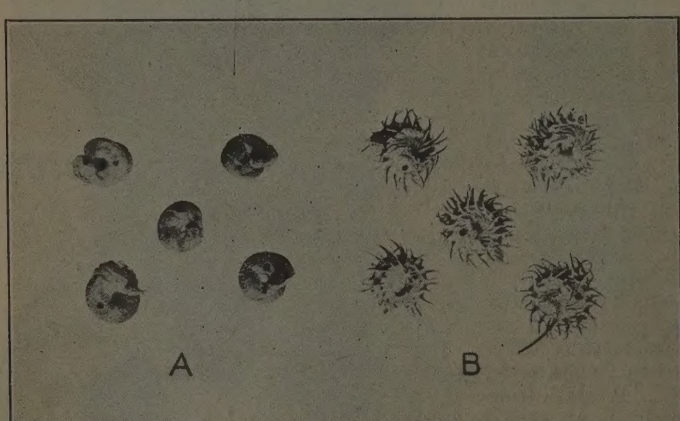

FIGURE 6.—Alfalfa pods (A) and bur-clover pods (B) showing the exit holes made by the adult chalcids. About three times natural size

larvæ have completed their development, provided there is sufficient moisture remaining in the seed pods and the temperature is sufficiently high, they transform to the pupal stage (fig. 1, *c*), and after resting for a period of from 5 to 40 days the insects emerge as winged adults. In cases where the seed pods have already become dry and ripe or where the temperature has become low, owing to the approach of fall, the larvæ may remain for an indefinite period within the hollowed-out seed until both temperature and moisture are favorable for their changing to the pupal stage.

The adult chalcid (fig. 1, *a*) emerges from the pupal stage as a small black insect resembling a tiny wasp. It gnaws its way out through the shell of the seed, then gnaws a hole through the seed pod (fig. 6), and comes out through this opening, leaving the destroyed, empty seed behind. It is then ready for feeding and mating, and egg laying in other susceptible seed, thus continuing the destruction indefinitely.

SEASONAL HISTORY

The seasonal history of this insect varies greatly in the different sections of the country. This variation is due largely to differences in climate.

In the warm irrigated valleys of the Western and Southwestern States the adults emerge from hibernation quarters early in the spring, often as early as March. Egg laying starts as soon as either bur clover or alfalfa pods are of sufficient size, and a continuous series of generations are carried through the summer upon developing seeds. These generations follow one another every 30 to 40 days throughout the season and sometimes continue until late in November before the insect again goes into hibernation.

In the Middle Western States and in the colder northern areas the adults from hibernating larvæ may not emerge until early June, and each succeeding generation requires a much longer period for development; consequently there are only one or two generations, possibly three, during the season.

In southern Arizona, where the mean temperature for the season is well above 80° F., as many as six generations have been observed; while in the Uintah Basin of northern Utah, where the mean temperature during the alfalfa-seed producing months falls much below this, as few as two generations have been observed.

This difference in the number of generations naturally has a considerable effect upon the percentage of infestation sustained by alfalfa-seed crops in the various districts. However, the effect of the number of generations is less marked than would seem probable, because of the relation of insect parasitism to the chalcid problem. It so happens that in the warmer districts the parasites are able to develop nearly as rapidly as the chalcids themselves, hence the parasitic destruction of chalcids is greater in these warmer valleys, and frequently the injury to seed is reduced to a greater extent by these parasites in the warmer sections than in the colder ones. Therefore, owing to these counter influences, the percentage of damage remains nearly the same in all these sections in spite of varying temperature conditions.

HIBERNATION

The chalcid passes the winter in the hibernating condition, as a larva within alfalfa seed. These larvæ are found in seeds on the ground in alfalfa fields or along fence lines and ditch banks throughout the season. A great number of seed pods or seeds are found on the surface of fields where seed crops have been removed the previous year. Screenings around alfalfa straw stacks and the seeds of bur clover contain many hibernating larvæ. Therefore, it may be readily understood that the destruction of these seeds is one of the logical and simple means of reducing the damage caused by the insect. This subject is discussed more fully under the heading of control measures recommended for this pest.

HABITS OF THE INSECT

The chalcid adults are most active in warm weather, but often seek shade in the heat of the day. They are frequently seen in con-

sideraole numbers flying over alfalfa-seed shocks or swarming over the mower or driver when the seed crop is being cut. Ranchers often complain of their getting into the eyes, and frequently they confuse them with gnats. The writer has observed them to be so numerous in the air over a roadway adjoining an alfalfa field that a man's clothing would soon become covered with hundreds of the little black insects. The adults apparently feed in the alfalfa blossoms, and many remain alive for several weeks where conditions are satisfactory. In the warm, irrigated fields of the Southwestern States, where excessively dry conditions prevail in midsummer, many of the larvæ developing within the seeds go into a resting stage scientifically known as æstivation; in this condition they may remain in the dried seeds for a period lasting one or even two years. If these seeds are distributed during that time by man or through natural agencies to other localities, the adults upon issuing infest alfalfa-seed fields in such places. This makes the control problem more complicated.

NATURAL ENEMIES

The chalcid larvæ in many cases are destroyed by small parasitic insects of about the same size as the chalcid itself. In many alfalfa-growing sections these parasites often reduce the numbers of the chalcids to such an extent that the damage is not nearly so great as it would be if the parasites were not present. These little insects lay their eggs within the seeds already infested with the chalcid larvæ, and the parasitic larvæ entirely consume the developing seed pest. There are ten kinds of these parasites already known as destroying the chalcid larvæ, but only three of these exert any great influence in their control.

CONTROL MEASURES

The control of the clover-seed chalcid is extremely complicated because of the many varying conditions under which the insect is encountered, its widespread distribution, its habits of development, and its remarkable ability to maintain itself. The conditions under which it is found are often extreme as regards climate, soil, and cultural practices, and any proposed control measures must be adapted to meet them. Fortunately, however, many methods for reducing the numbers of this pest are known, and these, if properly used, will save the ranchers much loss in many localities.

In the paragraphs that follow the known means of reducing the damage from this pest are outlined.

CULTIVATE ALFALFA IN FALL AND WINTER

It has already been shown that much loose seed and many seed pods containing chalcid larvæ fall to the ground during the process of harvesting, and these overwintering forms give rise to the following year's infestation. Under Arizona conditions the larvæ in these seeds can readily be destroyed by thoroughly cultivating an alfalfa-seed field at some time during the fall or winter. The covering of the seed and the exposure to moisture cause the infested seed to mold and decay, thus destroying the hibernating larva. An alfalfa culti-

vator, a disk, or a spring-tooth harrow are the best implements for doing this work. The seeds need not be covered to a great depth to destroy the larvæ within, but at least 2 inches of the topsoil should be disturbed. The time for this cultivation will depend largely upon the farm practices of the rancher concerned. In case the stand of alfalfa is very thin and it is desired to seed one of the small grains, such as barley or oats, in the alfalfa field, this cultivating can be done in the early fall. On the other hand, if the alfalfa-hay crop is not to be supplemented by the addition of a small-grain crop, the cultivation may take place later in the winter.

CLEAN UP FENCE LINES, DITCH BANKS, AND WASTE PLACES

In winter cultivations, an effort should be made to cover as much of the field as possible. This should include the ditch banks and as much of the fence line as can be reached with the cultivator.

FIGURE 7.—An alfalfa-seed field with check ridges and fence lines burned over to destroy the hibernating larvæ of the chalcid. (Urbahns)

When this cultivation is completed, all remaining areas should be cleaned up and burned over. (Fig. 7.) Ditch banks can often be better cultivated after burning than before. Irrigation ditches often need to be rebuilt each year, regardless of the benefits to be derived from eliminating hibernating chalcids. The cleaning of fence rows and other waste places, however, should not end with the winter operations but should be continued throughout the season. The first generation of the chalcid is often allowed to develop unmolested along the borders of an alfalfa field or along ditch banks (figs. 8 and 9), and these breeding places serve to reinfest the entire field when the alfalfa seed is starting to mature. If one or more hay crops are removed before allowing the seed crop to develop, the uncut alfalfa should be destroyed after each cutting and not allowed to go to seed. Some ranchers follow the practice of pasturing the early alfalfa in the spring instead of cutting for hay, and this often results

in a high seed yield and low chalcid infestation. This low infestation is probably due to the fact that all the alfalfa growing in waste places is eaten off and seeds are not allowed to develop and harbor an early generation of the insect. An admirable method, one which

FIGURE 8.—The ditch bank, 3½ rods wide, with its neglected alfalfa, was a place of breeding and hibernation for the chalcid—a source sufficient for the infestation of surrounding fields. (Urbahns)

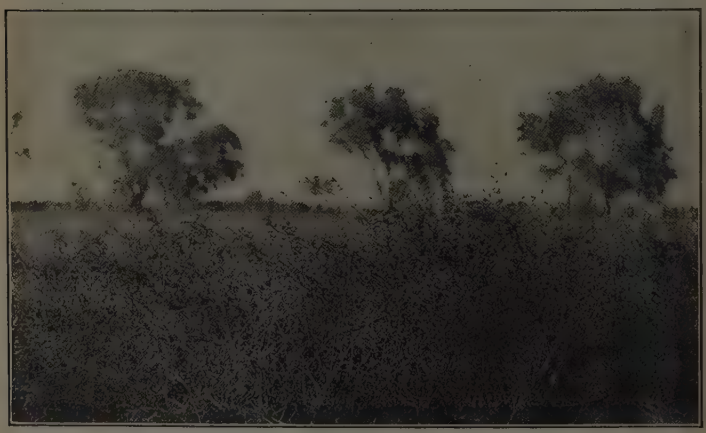

FIGURE 9.—The rank growth of dry alfalfa shown on this ditch bank was loaded with infested seed pods in which a multitude of chalcid larvæ were hibernating. (Urbahns)

not only destroys chalcids but also saves much time and labor, besides killing weed seeds and other insect pests, is the practice of fencing all ditches and ditch banks and then destroying uncut alfalfa by pasturing with either sheep or cattle.

CLEAN UP STACK YARDS, SCREENINGS, AND WASTE

In alfalfa-seed growing districts one may often see alfalfa straw stacks (fig. 10) around which the screenings have been left throughout the winter and early spring, without any attempt to clean up the threshing grounds. This is a big mistake. If the straw stack is to be used for feed, it should be entirely consumed before the weather is warm enough to allow the chalcids to emerge. All the screenings around these stacks should be cleaned up so thoroughly that no sign can be found of even the location of last year's threshing operations. In this way infestation can be kept down. If this is not done, all other measures may be rendered ineffective.

DESTROY ALL BUR CLOVER

As has been previously mentioned, bur clover in many localities grows abundantly in alfalfa fields and along ditch banks surround-

FIGURE 10.—An alfalfa straw stack, showing the ground covered with screenings in which many chalcid larvæ were hibernating. (Urbahns)

ing such alfalfa fields. In these localities the chalcid develops an entire generation in the seeds of these wild plants before seed pods have started to develop on alfalfa in the fields. Under such conditions all bur clover should be destroyed before its seed pods complete their development. Bur clover can best be destroyed by cultivation in late winter or early spring or by pasturing or burning over the fence lines, ditch banks, and other waste places.

STACK DELAYED CROPS

If it is intended to delay for any length of time the threshing of alfalfa after it is harvested, it should be stacked in large, well-placed stacks rather than allowed to lie on the field in small bunches, as many adult chalcids are likely to issue from it soon after cutting. In this case they serve to reinfest neighboring fields or alfalfa grow-

ing in waste places, and thus assist in increasing the chalcid population. Frequently a rancher may discover that a field is severely infested and may attempt to save a portion of the forage value of the crop by pasturing the field. (Fig. 11.) This should not be

FIGURE 11.—A severely infested alfalfa-seed field which had been abandoned. Infested pods cover the ground, where they offer favorable conditions for the hibernation of the chalcid. (Urbahns)

FIGURE 12.—Interior view of an alfalfa-seed cleaning plant, where the infested seeds, together with weed seeds, are removed before the product is sold for planting. (Urbahns)

done, because it results in scattering the infested seed and seed pods by the animals in the field; instead, the crop should be harvested for hay and well stacked, so that the sweating process will kill a great majority of the chalcids that are still within the seed.

PLANT CLEAN SEED

In sowing alfalfa, it is important to use only the best recleaned seed. Most of the seeds containing chalcid larvæ can be removed by thoroughly recleaning all alfalfa seed before planting. The cleaning of alfalfa seed to remove infested seeds and weed seeds can be done with a small fanning mill, but as a rule the results are more satisfactory if the work is done in a well-equipped seed-cleaning plant. (Fig. 12.) Many farmers in alfalfa-seed districts practice the sowing of a grade of seed known as "thresher-run" seed, which may have been grown on their own fields or may have been purchased from another locality, but is used with the idea of effecting a saving in the cost of alfalfa seed. The use of such seed, which sometimes contains infestations as high as 10 to 25 per cent, results in a poor stand, and the hibernating chalcid larvæ soon give rise to a new generation of chalcids in the seed field. This practice of using uncleaned seed is one that should be abolished everywhere, as it can not be justified by any consideration.

ADOPT UNIFORM PLAN FOR HARVESTING THE SEED CROP IN EACH LOCALITY

Each locality should, through some interested organization, work out a uniform plan for producing and harvesting alfalfa-seed crops. This plan, besides observing the recommendations given, should be arranged after consideration has been given to certain factors which are rarely constant for any two alfalfa-seed producing districts of the United States. The points to be considered are: The time of starting the seed crop in the spring, the time of cutting the seed crop as regards maturity, and whether one or two seed crops per year are most desirable for the given locality.

In each locality the time of starting the seed crop in the spring should be uniform. Very frequently it happens that one rancher takes off one hay crop and allows the next crop to go to seed, while his neighbor cuts two hay crops and allows the third growth to go to seed. This means that the chalcids which escape from the early seed crop of the first rancher will infest the later seed crop of his neighbor; the cycle is thus continued year after year and the injury caused by the infestation greatly increased. The question of which procedure should be practiced must be left to the decision of each community.

Provided the soil and moisture conditions are satisfactory, an alfalfa-seed crop should be hurried through to maturity, immediately cut, and threshed as soon as dry. The seed crop should be handled in such a way that the seed will mature at approximately the same time. This can usually be accomplished by practicing thorough spring irrigations, thus furnishing a reserve of moisture in the subsoil that will be available for the seed crop later in the season. Under this method the alfalfa plants will come to full podding at the same time instead of bearing a mixed irregular setting of seeds such as results from later irrigations. This will prevent much infestation. Often, however, because of the lack of ideal fruiting conditions, a stand may fail to set a heavy crop of seed, and then it seems necessary that a top crop be allowed to develop and that cutting be

delayed from two to three weeks. This procedure, while often giving a high seed yield, will greatly increase the percentage of infestation and will assist in distributing the chalcid pest for another year. In many cases where a high seed yield is secured by this method it is because parasites, as mentioned in a previous paragraph, have controlled the chalcids. Whether or not this procedure should ever be practiced depends on a careful examination of the field, either by the grower or by some other well informed person. In case a heavy infestation is found in the early pods the field should be harvested for seed or cut for hay. In case infestation is found to be light or entirely lacking the growth can be allowed to continue and the crop cut at a later date.

The number of crops of seed produced in different localities will vary. In the warm southwestern irrigated valleys, especially in southern Arizona and in California, an attempt is often made to produce two crops of alfalfa seed in the same year. This sometimes produces a very satisfactory total yearly yield, but the second crop in practically all cases is more heavily infested with chalcids than is the first one, and the procedure thus becomes a detriment to alfalfa-seed production as a whole. Also it is likely to result in a reduction of the first crop of the following year that is great enough to more than offset the gain which seemed to have been made by harvesting the second crop the previous fall.

ORGANIZE EFFORT AND PRACTICE COOPERATION

While it is recognized that much can be accomplished by an individual farmer if he will follow the control methods outlined in the preceding pages, yet final and complete success can come only through the cooperation and organized effort of the alfalfa-seed growers in any particular locality. Unless this is done, the efforts of an individual may be greatly counteracted by the faulty practices of a neighboring seed grower. One of the first duties of an alfalfa-seed growers' organization should be that of maintaining a warehouse or seed-cleaning plant (fig. 12) where nearly all infested seeds may be removed before the product is placed on the market and where weed seeds and foreign matter may also be cleaned out in order that the product may command high market prices.

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